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SUBJECT: ECS – "Rangeland Management Before, During, and After Drought"

Purpose: To distribute information to the field.

Expiration Date: December 31, 2002

The attached publication is provided in order to assist NRCS employees, consultants, and livestock producers to plan for drouught as a normal part of the livestock business.

File the attached University of Arizona Extension Bulletin AZ1136 titled, **"Rangeland Management Before, During, and After Drought"** in the Range Tech Note section of your office reference library.

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Rangeland Management Before, During, and After Drought

Introduction

Rangeland and livestock management in the southwestern U.S. presents many formidable challenges. Environmental regulations, cattle prices, and drought are just a few factors that contribute to the management challenges of the range-livestock industry. Although rangeland and livestock managers have little control over any of these variables, drought may be the least controllable or predictable.

Drought is defined by the Society for Range Management as "…prolonged dry weather when precipitation is less than 75% of the average amount" (SRM 1989). Using this criterion, drought occurred with the following frequency over a 40-year period from 1944-1984: 43% of the time in the southwestern U.S., 27% of the time in the southern great plains, 21% of the time in the northern great plains, and 13% of the time in the northwestern U.S. (Holechek et al., 1998). It is obvious that when it comes to drought in the southwestern U.S., it is not a question *if* drought will occur, but rather when will it occur, how long will it last, and *are you prepared*? Livestock operators must plan for drought as a normal part of the range-livestock business.

Principles of Drought and Range-Livestock Management

Ranchers depend upon the natural production of rangeland grass and other forage plants to feed their free-ranging livestock. In reality, ranchers utilize domestic livestock to market the forage that is produced on the range. When you think about drought management from this viewpoint, it becomes obvious why it is important to have an understanding of how drought affects rangeland forage production, and more importantly, how your management practices can help buffer the consequences of drought when it comes.

Drought Affects Individual Plants

• General Plant Response

Drought or water stress affects virtually every physiological and biochemical process in plants (Hanselka and White 1986). As water stress progresses, cell division slows down, enzyme levels decline, and chlorophyll formation may cease. Leaf stomata close, slowing transpiration and photosynthesis, which in turn, slows shoot and leaf growth. Buds of perennial grasses may be damaged to such a degree that they cannot produce shoots (i.e., forage) in subsequent years. Seed heads may not develop, or, extra-dry soil conditions may prohibit seed germination altogether. In extreme cases, carbon dioxide assimilation ceases, senescence is induced, and plants die.

• Root and Shoot Growth

To survive, perennial plants must accumulate both above ground (shoot growth) and below ground (root growth) biomass through the processes of photosynthesis, transpiration, and respiration. During drought, healthy root systems are essential to extract remaining soil moisture. Under extreme drought conditions, however, limited soil moisture may be inadequate to support shoot growth. When shoot growth is limited, adequate carbohydrates (i.e., plant food) may not be manufactured to replace roots that normally die back a little each year. The combined effect of drought is a downward spiral where roots are unable to extract moisture and minerals from the soil, which, in turn, limits shoot growth and food production of plants. In severe cases, wide-spread plant death may occur across parched landscapes.

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Rangeland Condition and Drought

Although all rangelands are adversely affected by drought regardless of condition, rangeland in fair or poor condition is more adversely affected and recovers more slowly than rangeland in good or excellent condition (Fig. 1). There are several reasons for this. Higher range condition ratings may mean higher diversity of plants that possess different growing seasons (e.g., warm and cool season plants) and rooting habits (e.g., shallow-, medium-, and deep-rooted plants). This increases opportunities for plant communities to exploit the various temperature and soil moisture regimes that occur across arid and semi-arid rangelands (Fig. 2). With improved range condition there is usually adequate cover (i.e., vegetation, litter, rocks) to prevent accelerated soil erosion. Better soil stability improves the capacity of range sites to retain soil moisture and grow the kinds and amounts of plant species they are inherently capable of producing.

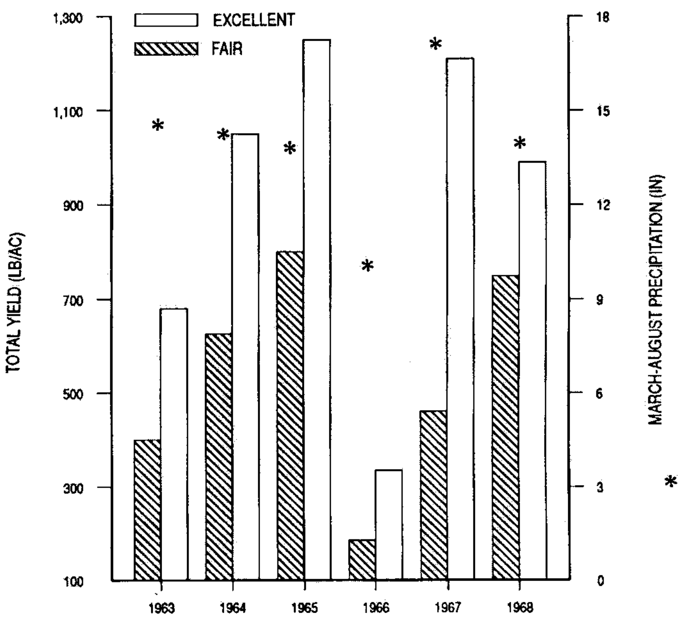

Figure 1. The influence of range condition (excellent vs. fair) and drought on perennial grass and forb production (lb/acre) on a clayey range site near Cottonwood, South Dakota (Hanson et al., 1978).

Intensity, Frequency, and Timing of Grazing

The degree to which drought impairs the range's potential for future forage production depends on the intensity, frequency, and timing of grazing. Range-livestock managers can control each of these factors through their management practices.

The phrase, "intensity of grazing" refers to the number of animals and duration of grazing on a particular pasture (i.e., stocking rate). Heavily grazed pastures show greater reductions in forage production during drought than lightly or moderately grazed pastures. Excessive removal of green leafy material during the growing season reduces root growth and replacement, decreasing the ability of plants to harvest solar energy and soil moisture needed for maintenance and growth. Conversely, moderate grazing causes little reduction in root growth or plant vigor (Fig. 3). For example, moderately grazed grasses can continue to extract soil moisture even when it drops as low as 1-2% (Hanselka and White 1986). On the other hand, heavy grazing can cause plants to permanently wilt when there is still 6-8% soil moisture available.

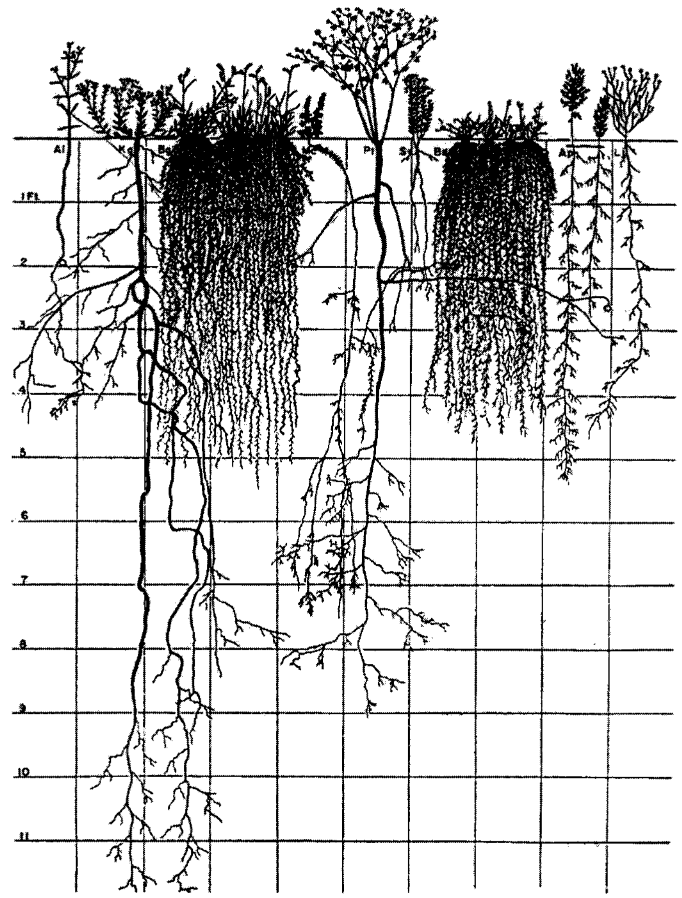

Figure 2. Roots of different grassland plants draw their moisture from different soil layers (Stefferud 1948). Roots of some native plants extend to depths of 20 feet or more. Al, narrow-leafed 4-o'clock (*Allionia linearis*); Kg, prairie false boneset (*Kuhnia gultinosa*); Bg, blue grama (*Bouteloua gracilis*); Mc, globemallow (*Malvastrum coccineum*); Pt, a legume (*Psoralea tenuiflora*); Ss, (*Sideranthus spinulosis*); Bd, buffalo grass (*Buchloe dactyloides*); Ap, western ragweed (*Ambrosia psilostachya*); and Li, skeleton weed (*Lygodesmia juncea*).

Frequency of grazing refers to the number of times individual plants are grazed during the growing season. Frequency of grazing is closely related to grazing intensity because the probability of a plant being grazed more than once increases with higher stocking rates. Plants that are grazed repeatedly while photosynthetically active may have little or no opportunity to grow new leaf material between successive defoliations and become stressed for similar reasons described for grazing intensity.

Timing of grazing deals with the time of year that plants are grazed, and therefore, their physiological or morphological stage of development. Plants are more susceptible to grazing during certain times of their life cycle. For example, many native perennial grasses are most sensitive to grazing from the late boot to early head-

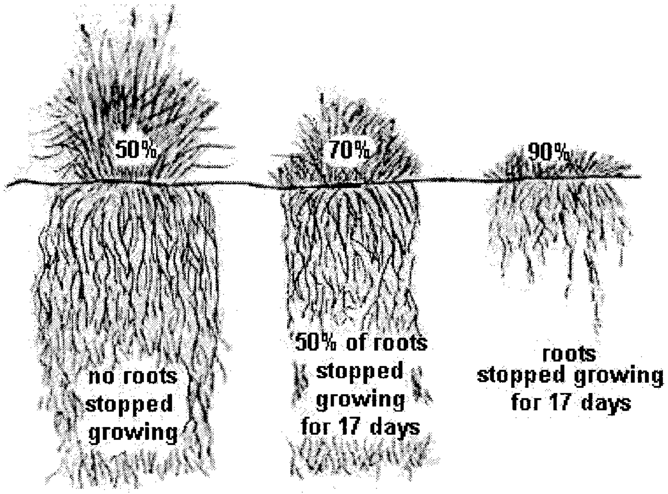

Figure 3. Root development in relation to top removal (Leithead 1979).

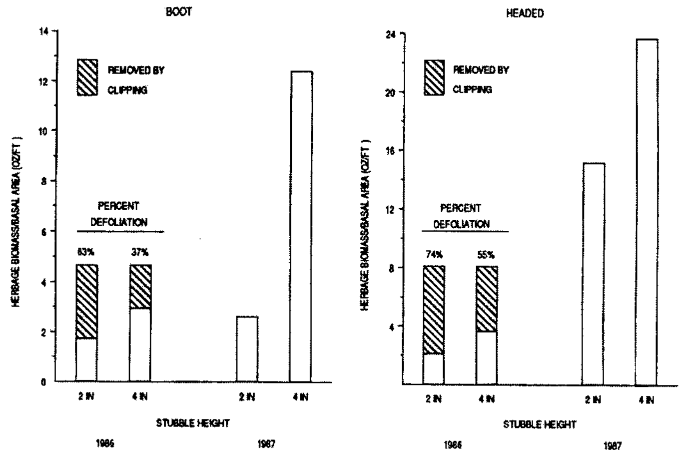

Figure 4. Herbage yield in 1987 in relation to herbage removed in 1986 (Reece et al., 1991). Precipitation was above average in both years. Needle-and-thread (*Stipa comata*) plants were clipped to a 2- or 4-inch stubble height. Plants were clipped only once on May 15 (late boot stage) or on June 15 (fully headed stage). *Notice that production was greatly reduced in 1987 significantly when plants were clipped to a 2-inch height during the "boot" stage in 1986.*

ing stage (Fig. 4). This is when meristems (i.e., growing points) in many rangeland grasses become elevated and are most susceptible to removal by grazing animals. Once meristems are removed, plants must initiate growth from basal buds which requires much more of the plant's energy than regrowth from meristems. Plants that are continually forced to regrow from buds may reduce or even eliminate the production of new buds which can limit forage production in subsequent years.

Management Before Drought

Advance Planning is Critical

Planning for the "next" drought must occur in advance because management options decline as drought intensifies. The primary goal in every drought management plan should be to protect rangeland plants before and during drought years so that fast recovery can be achieved in years of higher precipitation. Each individual operation should tailor a drought management plan in accord with the ranch's unique vegetation, topography, and management objectives.

Stocking Rate

Stocking rate, because of its relation to grazing intensity and frequency, is considered the most important of all range management decisions (Holechek et al., 1998). Stocking rates should be calculated to leave enough standing residual vegetation (i.e., plant material from previous year's growth) after the grazing season to protect the soil and ensure sustainable forage production. Although it is obviously impossible to grow forage without rain, residual vegetation and associated litter (i.e., detached plant material) can improve the effectiveness of rainfall received and reduce drought impacts in several ways. To illustrate, after a raindrop reaches the soil surface it either: 1) soaks into the soil (infiltration and percolation), 2) evaporates, or 3) runs off. Infiltration and percolation are critical to forage production because water must penetrate the soil profile before it can be used by a plant's root system. Residual vegetation facilitates infiltration and percolation by reducing evaporation losses (i.e., residual vegetation lowers soil surface temperatures), protecting the soil from erosion (i.e., residual vegetation provides more soil cover and less bare ground), and providing a favorable micro-climate for seedling growth (i.e., residual vegetation is a source of organic matter). The converse is true for overgrazed areas. Hence, residual vegetation left ungrazed is not wasted because it enhances the ability of the land to endure drought conditions and to be more productive in the long-term.

In a perfect world, you could reduce stocking rates to prevent excessive grazing during dry times, and increase stocking rates to take advantage of more abundant forage during high precipitation years. However, this may not be practical in unpredictable arid environments because cattle numbers must be determined before forage production for the next growing season is known. Fluctuating cattle prices further complicate the feasibility of flexible stocking rates. To deal with this uncertainty in southeastern Arizona, Martin and Cable (1974) recommended a constant stocking rate at or below 90% of the average long-term carrying capacity, with appropriate reductions during prolonged severe droughts. They ascertained the 90% stocking level during a 10-year-study where cattle utilized 40% of the available key forage production, (leaving behind approximately 60% of the annual production as residual vegetation). The 40% utilization level resulted in improved range condition, economic stability, and permitted a gradual increase in stocking rate.

Grazing System

Every grazing management plan should include a proper grazing system that promotes stable or improved range condition. Grazing system decisions, like stocking rate decisions, are site specific and must consider the unique vegetation, topography, and management goals and objectives for the range. Grazing systems should be planned to give grazed areas periodic deferment or rest, and to set aside ungrazed areas to be used during drought emergencies. No grazing system will be biologically or economically sustainable if stocking rates exceed forage supply. Holechek et al. (1998) discusses several grazing systems that have been implemented in the southwestern U.S.

Watch for Drought Signs

No one can predict droughts. Even meteorologists, with all their sophisticated equipment, have difficulty pinpointing when droughts will occur within a particular geographical region. Drought is not obvious during the initial stages, but is easily observed after reaching full impact. Good managers recognize potential drought signs and take action *before* this occurs. This process begins with keeping good records to track monthly trends in a few key environmental variables.

Rainfall is obviously the most important variable to monitor. Install several rain gauges in strategic locations on the range. Permanent vegetation monitoring sites are good places to install rain gauges. Placing a known amount of light machine oil or transmission fluid in the rain gauge will help prevent recent rainfall from evaporating and facilitate periodic monitoring. Placing a known amount of antifreeze will prevent precipitation from freezing during colder months. Subtract the inches of oil, transmission fluid, or antifreeze placed in the gauge before taking a rainfall reading.

Soil moisture readings taken from 3 rooting depths of key forage species (e.g., 6 inches, 1 foot, and 3 feet) will indicate whether various key forage species have adequate moisture for growth. Squeeze the soil in your hand. Does it form a ball? If so, you probably have adequate soil moisture for growth. If it doesn't form a ball, but your hand feels cool, you probably have some soil moisture left. If the soil is completely dry and blows away, there is likely not enough moisture to sustain plant growth.

Plant growth can be monitored by placing a small exclosure (sometimes called a utilization cage) in a pasture. A utilization cage can be used to estimate forage production in a particular year (and pasture) without grazing. Periodically measure and record the height of key forage species within the cage. Every inch of growth equates to pounds of forage available for animal consumption. To estimate the average forage production within a pasture, you will need to clip, dry, and weigh forage from several small sample plots (Interagency Monitoring Manual, 1996). Utilization cages must be moved every year to prevent accumulation of decadent plant material which can bias yearly forage production estimates.

Low **air temperatures** occurring several nights in a row during the growing season can greatly slow plant growth and mimic drought conditions. Several nights of less than 60^0 F may slow growth of warm-season plants (e.g., blue grama, side oats grama), while several nights of less than $40\text{-}50^0$ F may slow growth of cool season plants (e.g., western wheatgrass, needle grasses). On the other hand, prolonged hot daytime temperatures can increase evapo-transpiration and accelerate drought conditions.

Although some of these measurements may appear crude, they can provide a harbinger of drought when considered collectively and compared to monthly trends over several years. The more years of data you can collect, the better idea you will have of how key environmental variables will affect your operation. Keep in mind that while drought is generally considered below average rainfall for an entire year across a broad geographic area, drought conditions may also occur *locally* when timing or amount of rainfall is unfavorable for plant growth, or where temperatures are abnormally low or high. This is why it is important to monitor monthly trends in environmental variables at several key locations.

Management During Drought

Ranchers should consider a variety of management options to minimize the effects of drought. The more options you have, the greater flexibility there will be to survive drought conditions. Following is a summary of drought management suggestions (adapted from Hanselka and White 1986, unless otherwise indicated). Although there is no "cookbook" approach to drought management, many of these points are *range management principles* that can be applied to all ranches. Other suggestions may not be practical for some operations for a variety of reasons (e.g., legality, costs, and benefits). No one knows better than the ranch manager what will or will not work on a particular ranching enterprise. The following is merely a laundry list for consideration.

Rangeland/Forage Management

1) **Continue to monitor and maintain plant vigor and range condition to the extent possible.** Drought increases the rate of natural die-off of plant roots. However, healthy vigorous perennial grasses with a good root system suffer less damage and maintain production longer into drought. They also recover more quickly once rainfall occurs.

2) **Monitor utilization of preferred plants (sometimes called "key forage" species).** Moderate use of key forage plants can serve as a warning to determine when livestock moves or adjustments are needed. Careful monitoring of utilization levels of these plants can help avoid the critical mistake of over-utilizing an entire pasture when plants are drought-stressed.

3) **Provide adequate, accessible, good-quality water.** Poor quantity and quality of water can decrease animal distribution, intake, and performance. A well-

designed pipeline system with a good source of clean water is the best way to ensure that adequate water is strategically located throughout the range. Consider hauling water to areas with adequate forage if good quality water is not available during drought (Bartlett et al., 1994).

4) **Use emergency forage that has been set aside for drought conditions.** Rest pastures specifically for this purpose. Buy and store hay or other feeds while plentiful and inexpensive. Dense cactus growth in certain areas may present an opportunity for cactus to be burned to provide emergency feed (e.g., cholla, prickly pear). Keep in mind that high rainfall years may present an opportunity to seed abandoned fields or barren areas with adapted forage plants that can be used during emergency drought conditions.

Livestock Management

1) **Develop an annual (flexible) timetable for making decisions** on stocking rates, livestock movements, range improvement practices, supplementation, and marketing in relation to seasonal patterns in forage production and quality. Evaluate several options pertaining to each of these factors. For example, you may need to drastically alter your grazing management plan during drought by moving animals out of pastures early, or by reducing your herd, but you may be able to graze pastures that have received localized rainfall. Every drought will result in a different set of circumstances so it pays to monitor each situation and adjust your management practices accordingly.

2) **Use range management techniques to distribute livestock more uniformly.** Herding, drifting, and strategic placement of salt, supplements, along with water developments, and strategic fencing can be used to promote better animal distribution.

3) **Determine the amount of money that can be spent on animal feed and supplements.** During extreme droughts, determine if it is economical to implement "substitute feeding" of hay or other supplements in a drylot. This relieves grazing pressure on plants that are already stressed and reduces energy expenditure of animals searching for scarce rangeland forage. See Sprinkle (1998) for recommendations on rangeland supplementation during drought.

4) **Select and cull cows and replacement heifers on the basis of behavioral characteristics.** Some individual animals use only a very small amount of the available range, while others use the range more extensively (Howery et al., 1996). These behaviors are apparently passed from mother to offspring and may be used as a basis to select or cull cows and replacement heifers based on desirable and undesirable behavioral traits (Howery et al., 1998).

5) **Once drought is recognized, reduce the herd as soon as possible so it is in balance with forage supply.** Market prices tend to be highest at the beginning of a regional drought. If stocking has historically been heavy, the number of animals removed will probably need to be greater than in areas where light or moderate stocking has been implemented.

   - Sell before animals have lost excessive weight so that sufficient rangeland forage is available to carry the breeding herd.
   - Sell weaned calves, inferior or nonbreeding cows, low fertility bulls, and inferior heifers that will not contribute to building the herd.
   - Wean early so that productive cows can regain condition and cycle sooner. This prevents delays or reductions in breeding and calving activities. Animal condition is one of the most important factors in next year's breeding success. Weaning also reduces forage demand and decreases nutrient requirements because dry animals eat less than lactating animals.

Management After Drought

After drought finally breaks, surviving plants may grow to above average heights and produce a legion of seed stalks. Drought-induced mortality thins plant communities and reduces competition for nutrients and moisture. This gives the surviving plants an opportunity to become more productive and vigorous. Although surviving plants may be more vigorous after drought breaks, total forage production may actually be lower than normal because there are less plants per unit area (Reece et al., 1991). This trend may continue for several years following severe droughts.

After drought, the color green can have a profound psychological effect, tempting you to deviate from your best-laid drought recovery plans. However, you should resist the temptation to restock to pre-drought levels no matter how "green" the range appears. Animals graze forage, not acres, and stocking rates considered to be moderate during a "normal" precipitation year may be heavy during and following dry years. Overgrazing after drought will damage surviving plants and ultimately require a much longer period of rest and recovery than with conservative, incremental restocking strategies. The year following drought should be devoted as much as possible to improving plant vigor and restoring protective residual vegetation and plant litter. Pastures most likely to provide the largest increases in forage production should receive highest priority.

Grazing management practices that benefit plant recovery in the years immediately following drought (listed in order of efficacy) include (adapted from Reece et al., 1991):

1) **Rest pastures for an entire growing season or more following severe droughts.** Complete rest is the most effective and fastest way to achieve range recovery.

2) **Use pastures only when key forage species are dormant for one or more growing seasons.** The dormant season is typically the least harmful time to graze perennial grasses.

3) **Use pastures when the least desirable species are green and palatable.** By manipulating timing of grazing in this way, you can shift grazing pressure away from key forage plants. For example, animals are likely to prefer green (but less desirable) plants over key forage plants when they are dormant.

4) **Defer grazing until after key forage species have produced mature seed.** After herbaceous plants produce mature seed, they are usually not as highly prized by livestock. Perennial grasses can generally tolerate grazing better during this period because they have completed their life cycle for the current growing season.

5) **Graze early growth after perennial grasses have reached the 4 to 5 leaf stage.** As this phrase suggests, this is when perennial grasses have produced at least 4-5 leaves during the vegetative stage. Perennial grasses are usually more tolerant of grazing during this period because their growing points have not been elevated. Animals should be removed from the grazing unit before key forage plants reach the early heading / late boot stage.

Summary

Droughts are a guaranteed but unpredictable phenomenon in the southwestern U.S. occurring, on average, about 4 out of every 10 years. Successful management depends on anticipating that drought will occur and planning in advance how to deal with it. Advance planning is critical because it allows you to consider a variety of options and make decisions early to avoid crisis situations. Delays in decision making often leads to intensification of the problem, economic loss, and long-term damage to rangeland resources.

There is no cookbook approach for proper drought management. It really boils down to the fact that sound range management practices that sustain or improve range condition will ultimately result in good drought management. Well-planned grazing practices that promote conservative forage use while sustaining high vigor of desirable plants is good insurance against drought.

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